

[0038] While a typical gas turbine engine like that described above and in the Lee reference may have a conventional configuration and operation, such an engine is modified as described herein, to include improved film cooling. Thus, one or more of the various engine components which are subject to heating from the hot combustion gases of the engine may be suitably cooled by bleeding a portion of the pressurized air from the compressor during operation, as mentioned previously.

[0039] These components usually include at least one metal wall **20**, as depicted in FIG. 1. The wall can be formed from a superalloy like those mentioned above, since those materials exhibit high strength at elevated temperatures. A portion of the wall is illustrated in plan view in FIG. 1; and a portion is also shown as a cross-section in FIG. 2. The thickness of the wall will vary, depending on the article in which it is incorporated. In many instances, e.g., for many aviation components, the wall has a thickness in the range of about 0.020 inch to about 0.150 inch (508 microns to about 3810 microns). For land-based components, the wall often has a thickness in the range of about 0.050 inch to about 0.300 inch (1270 microns to about 7620 microns).

[0040] The wall includes opposite inner and outer wall surfaces **24**, **26**. The inner or inboard surface of the wall forms the outer boundary of a suitable cooling circuit provided in the component which receives air bled from the compressor in any conventional manner. The outer surface **26** is exposed to the hot combustion gases **22** during operation (see FIG. 1), and requires suitable film cooling protection.

[0041] The exemplary component wall **20** illustrated in FIGS. 1 and 2 may be found in various components. They include the inner or outer combustor liners, turbine nozzle vanes, turbine nozzle bands, turbine rotor blades, the turbine shroud, or the exhaust liner. All of these components frequently incorporate various forms of film cooling holes or "passage holes" therein.

[0042] For embodiments of the present invention, passage holes **28** are arranged in a suitable row or other pattern (FIG. 1), along a selected span of the wall component **20**. As in embodiments of the Lee patent, passage holes **28** are identified by their "chevron" configuration. In preferred embodiments, each passage hole **28** extends longitudinally through the wall **20**, and diverges both longitudinally along the hole, and laterally across the width of the hole. Thus, each hole extends from an inlet **30** disposed flush at the inner surface **24** (see FIG. 2) to a chevron outlet **32** disposed flush at the outer surface **26**. As mentioned above, a portion of the pressurized air from the compressor is directed through the passage hole **28** (FIG. 1) as coolant air **33**, exiting at the chevron outlet **32**.

[0043] In preferred embodiments, each of the passage holes **28** includes an inlet bore **34**. The bore usually has a substantially constant flow area from its inlet end to its outlet end. As depicted in FIG. 2, the inlet bore has a longitudinal or axial centerline axis **36**. The bore itself can be thought of as the portion of the passage hole which remains cylindrical or substantially cylindrical, i.e., prior to the beginning of the chevron outlet. Thus, in FIG. 2, the inlet bore can be thought of as the section between points X and Y along axis **36**. The upward termination site of the inlet bore can be referred to as "bore outlet" **38**, which still lies below outer wall surface (exterior wall surface) **26**. The inlet bore can be inclined at a relatively shallow angle "A", relative to its inner or outer surfaces, which are typically parallel with each other. The

inclination angle A of the inlet bore is usually related to the typical inclination used for film cooling holes, e.g., about 20 degrees to about 45 degrees.

[0044] As mentioned previously, FIG. 3 is a plan view of the passage hole illustrated in FIG. 2, taken along line 3-3. The figure depicts passage hole inlet **30**, effectively bisected by centerline axis **36**. Inlet bore **34** is shown as extending from point X to point Y, i.e., ending as bore outlet **38**. The remainder of the passage hole from bore outlet **38** toward surface **26** (i.e., in a direction opposite that of inlet hole **30**) can be thought of as the "passage hole-exit"

[0045] With continued reference to FIG. 3, the bore outlet **38** terminates at a chevron outlet, generally designated as feature **40**. For most of its length "Z", the chevron outlet **40** comprises a pair of wing troughs, **42** and **44**. The wing troughs diverge longitudinally from a trough initiation site **39** (the "upstream" beginning of the troughs), to the exterior wall surface **26** (FIG. 2). The trough initiation site is usually located about 15% to about 35% of the length from bore outlet **38**, based on the total length of chevron outlet **40** along axis **36** (FIG. 3).

[0046] In some embodiments, the wing troughs are similar in size and shape to the wing troughs in the Lee patent mentioned previously, and usually have a substantially elliptical cross-sectional shape. As an example, the wing troughs may be substantially circular or partially circular.

[0047] The wing troughs **42**, **44** have a common surface region **46** between them. The wing troughs can be said to diverge laterally along this surface region, in a direction away from inner wall surface **24**, to eventually blend with outer wall surface **26**.

[0048] In some embodiments, the common surface region **46** comprises a valley or "floor" **48**, and a plateau **50**, adjacent the valley **48**. Plateau **50** rises above the valley, and extends along axis **36**, in a direction opposite hole inlet **30**, terminating at a site **52**, which is generally flush with outer wall surface **26**. It should be understood that the valley **48**, while below the level of plateau **50**, is still generally higher than the depth of the wing troughs **42**, **44**. Moreover, valley **48** can be considered an extension of the lower surface **54** (FIG. 2) of inlet bore **34** (usually an arcuate surface). As described below, the passage hole and chevron outlet geometry described in embodiments of this invention can be obtained by using certain types of drilling, machining, and cutting techniques.

[0049] As generally depicted in FIG. 2, plateau **50** is typically an elevated, relatively level feature rising above valley **48**. The top surface **56** of the plateau can be very flat, and somewhat parallel to the surface of valley **48**. However, as further described below, the shape, size and orientation of the plateau can vary considerably, as can any of the individual surfaces or "faces" of the plateau. As one example, the front face **58** of the plateau (see FIG. 3) can be substantially perpendicular to the surface of valley **48**. However, as shown below, the front surface is usually sloped, e.g., gradually decreasing in size (like a ramp) until merging into the valley surface **48**. In general, the shape and size of the plateau and the valley from which it rises are important factors in maximizing the diffusion of cooling air that is channeled through the passage holes. As further described below, another advantageous result is a reduced flow separation of the cooling air from outer wall surface **26**.

[0050] With reference to FIG. 3, the position of plateau **50** within the entire area of chevron outlet **40** may also be a significant feature for some embodiments. Each trough can be